for regeneration of the chemical reducing agent(s) used in ion exchange uranium enrichment cascades.

The ion exchange enrichment process may use, for example, trivalent titanium (Ti+3) as a reducing cation in which case the reduction system would regenerate Ti+3 by reducing Ti+4.

(ii) Especially designed or prepared chemical or electrochemical oxidation systems for regeneration of the chemical oxidizing agent(s) used in ion exchange uranium enrichment cascades.

The ion exchange enrichment process may use, for example, trivalent iron (Fe+3) as an oxidant in which case the oxidation system would regenerate Fe+3 by oxidizing Fe+2.

[61 FR 35604, July 8, 1996]

APPENDIX F TO PART 110—ILLUSTRATIVE LIST OF LASER-BASED ENRICHMENT PLANT EQUIPMENT AND COMPONENTS UNDER NRC EXPORT LICENSING AUTHORITY

NOTE—Present systems for enrichment processes using lasers fall into two categories: the process medium is atomic uranium vapor and the process medium is the vapor of a uranium compound. Common nomenclature for these processes include: first category-atomic vapor laser isotope separation (AVLIS or SILVA); second category-molecular laser isotope separation (MLIS or MOLIS) and chemical reaction by isotope selective laser activation (CRISLA). The systems, equipment and components for laser enrichment plants include: (a) Devices to feed uranium-metal vapor for selective photo-ionization or devices to feed the vapor of a uranium compound for photo-dissociation or chemical activation; (b) devices to collect enriched and depleted uranium metal as "product" and "tails" in the first category, and devices to collect dissociated or reacted compounds as "product" and unaffected material as 'tails' in the second category; (c) process laser systems to selectively excite the uranium-235 species; and (d) feed preparation and product conversion equipment. The complexity of the spectroscopy of uranium atoms and compounds may require incorporation of a number of available laser technologies.

All surfaces that come into contact with the uranium or UF6 are wholly made of or protected by corrosion-resistant materials. For laser-based enrichment items, the materials resistant to corrosion by the vapor or liquid of uranium metal or uranium alloys include yttria-coated graphite and tantalum; and the materials resistant to corrosion by UF6 include copper, stainless steel, aluminum, aluminum alloys, nickel or alloys containing 60% or more nickel and UF6-resistant fully fluorinated hydrocarbon polymers.

Many of the following items come into direct contact with uranium metal vapor or liquid or with process gas consisting of UF6 or a mixture of UF6 and other gases:

(1) Uranium vaporization systems (AVLIS).

Especially designed or prepared uranium vaporization systems that contain high-power strip or scanning electron beam guns with a delivered power on the target of more than 2.5 kW/cm.

(2) Liquid uranium metal handling systems (AVLIS).

Especially designed or prepared liquid metal handling systems for molten uranium or uranium alloys, consisting of crucibles and cooling equipment for the crucibles.

The crucibles and other system parts that come into contact with molten uranium or uranium alloys are made of or protected by materials of suitable corrosion and heat resistance, such as tantalum, yttria-coated graphite, graphite coated with other rare earth oxides or mixtures thereof.

(3) Uranium metal "product" and "tails" collector assemblies (AVLIS).

Especially designed or prepared "product" and "tails" collector assemblies for uranium metal in liquid or solid form.

Components for these assemblies are made of or protected by materials resistant to the heat and corrosion of uranium metal vapor or liquid, such as yttria-coated graphite or tantalum, and may include pipes, valves, fittings, "gutters", feed-throughs, heat exchangers and collector plates for magnetic, electrostatic or other separation methods.

(4) Separator module housings (AVLIS).

Especially designed or prepared cylindrical or rectangular vessels for containing the uranium metal vapor source, the electron beam gun, and the "product" and "tails" collectors.

These housings have multiplicity of ports for electrical and water feed-throughs, laser beam windows, vacuum pump connections and instrumentation diagnostics and monitoring with opening and closure provisions to allow refurbishment of internal components.

(5) Supersonic expansion nozzles (MLIS).

Especially designed or prepared supersonic expansion nozzles for cooling mixtures of UF6 and carrier gas to 150 K or less which are corrosion resistant to UF6.

(6) Uranium pentafluoride product collectors (MLIS).

Especially designed or prepared uranium pentafluoride (UF5) solid product collectors consisting of filter, impact, or cyclone-type collectors, or combinations thereof, which are corrosion resistant to the UF5/UF6 environment.

(7) UF6/carrier gas compressors (MLIS).

Especially designed or prepared compressors for UF6/carrier gas mixtures, designed for long term operation in a UF6 environment. Components of these compressors that come into contact with process gas are made of or protected by materials resistant to UF6 corrosion.

(8) Rotary shaft seals (MLIS).

Especially designed or prepared rotary shaft seals, with seal feed and seal exhaust connections, for sealing the shaft connecting the compressor rotor with the driver motor to ensure a reliable seal against out-leakage of process gas or in-leakage of air or seal gas into the inner chamber of the compressor which is filled with a UF6/carrier gas mixture.

(9) Fluorination systems (MLIS).

Especially designed or prepared systems for fluorinating UF5 (solid) to UF6 (gas).

These systems are designed to fluorinate the collected UF5 powder to UF6 for subsequent collection in product containers or for transfer as feed to MLIS units for additional enrichment. In one approach, the fluorination reaction may be accomplished within the isotope separation system to react and recover directly off the "product" collectors. In another approach, the UF5 powder may be removed/transferred from the "product" collectors into a suitable reaction vessel (e.g., fluidized-bed reactor, screw reactor or flame tower) for fluorination. In both approaches equipment is used for storage and transfer of fluorine (or other suitable fluorinating agents) and for collection and transfer of UF6.

(10) UF6 mass spectrometers/ion sources (MLIS).

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking "on-line" samples of feed, "product" or "tails", from UF6 gas streams and having all of the following characteristics:

(i) Unit resolution for mass greater than 320;

(ii) Ion sources constructed of or lined with nichrome or monel or nickel plated;

(iii) Electron bombardment ionization sources; and

(iv) Collector system suitable for isotopic analysis.

(11) Feed systems/product and tails withdrawal systems (MLIS).

Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by UF6, including:

(i) Feed autoclaves, ovens, or systems used for passing UF6 to the enrichment process;

(ii) Desublimers (or cold traps) used to remove UF6 from the enrichment process for subsequent transfer upon heating;

(iii) Solidification or liquefaction stations used to remove UF6 from the enrichment process by compressing and converting UF6 to a liquid or solid; and

(iv) "Product" or "tails" stations used to transfer UF6 into containers.

(12) UF6/carrier gas separation systems (MLIS).

Especially designed or prepared process systems for separating UF6 from carrier gas. The carrier gas may be nitrogen, argon, or other gas.

These systems may incorporate equipment such as:

(i) Cryogenic heat exchangers or cryoseparators capable of temperatures of −120 °C or less;

(ii) Cryogenic refrigeration units capable of temperatures of −120 °C or less; or

(iii) UF6 cold traps capable of temperatures of −20 °C or less.

(13) Lasers or Laser systems (AVLIS, MLIS and CRISLA).

Especially designed or prepared for the separation of uranium isotopes. The laser system for the AVLIS process usually consists of two lasers: a copper vapor laser and a dye laser. The laser system for MLIS usually consists of a CO_2 or excimer laser and a multi-pass optical cell with revolving mirrors at both ends. Lasers or laser systems for both processes require a spectrum frequency stabilizer for operation over extended periods.

[61 FR 35605, July 8, 1996]

APPENDIX G TO PART 110—ILLUSTRATIVE LIST OF PLASMA SEPARATION ENRICHMENT PLANT EQUIPMENT AND COMPONENTS UNDER NRC EXPORT LICENSING AUTHORITY

NOTE—In the plasma separation process, a plasma of uranium ions passes through an electric field tuned to the 235U ion resonance frequency so that they preferentially absorb energy and increase the diameter of their corkscrew-like orbits. Ions with a large-diameter path are trapped to produce a product enriched in 235U. The plasma, made by ionizing uranium vapor, is contained in a vacuum chamber with a high-strength magnetic field produced by a superconducting magnet. The main technological systems of the process include the uranium plasma generation system, the separator module with superconducting magnet, and metal removal systems for the collection of "product" and "tails".

(1) Microwave power sources and antennae.

Especially designed or prepared microwave power sources and antennae for producing or accelerating ions having the following characteristics: greater than 30 GHz frequency and greater than 50 kW mean power output for ion production.

(2) Ion excitation coils.

Especially designed or prepared radio frequency ion excitation coils for frequencies of more than 100 kHz and capable of handling more than 40 kW mean power.

(3) Uranium plasma generation systems.